Evaluation of the Effectiveness of Infantry Weapons Systems

By

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enemy came. He was beaten. I am tired. Goodnight!”

(Vicomte Turenne after the battle of Dunen 1658)

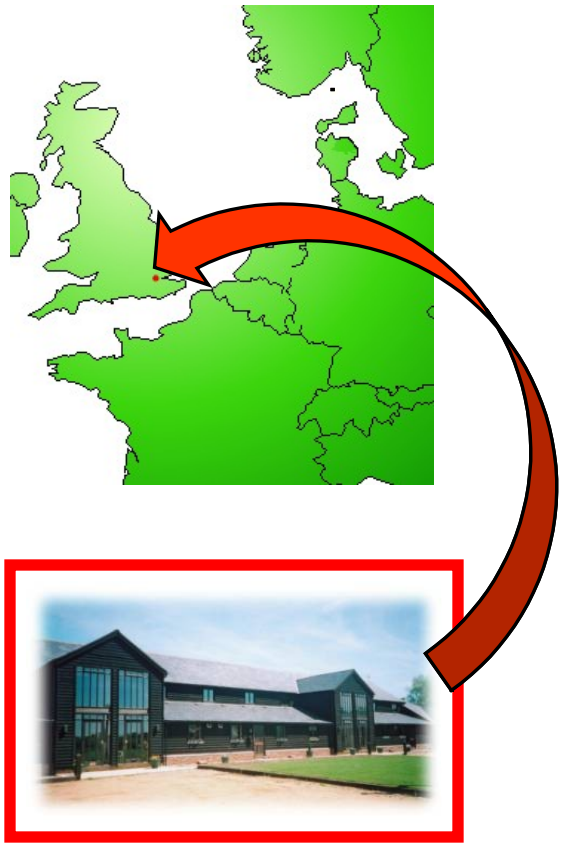
“I’d like to see the government get out of war altogether
and leave the whole field to industry.”

Joseph Heller

“The object of war is not to die for your country
but to make the other bastard die for his.”

General George Patton

Location & Capabilities



- Major Project Support
- Weapon and Munition Design
- System Modelling
- Software Development
- Safety and Risk Management
- Trials Management and Conduct
- Technical Services

Outline

- Why conduct modelling?
- Introduction to model and capabilities
- Soldier System Assessment Facility
- Summary

Why Conduct Modelling?

SDE

- Supports the systems approach to procurement
- Reduction of:
  - Cost
  - Time
  - Risk
- Allows repeatable and measurable investigation of scenarios that physical testing will not allow
- Early refinement of options

Why Conduct Modelling?

SDE

- Audit trail for decision making
- Informs Requirement and Systems Engineering Process
  - Supports optimisation and trade off studies
  - Provides MOP and MOE
- Supports Training Needs Analysis (TNA)
- Produces High Fidelity data for Low fidelity Operational Analysis models

Dual Purpose Model

Lethality

Probability of Initial Suppression:
- Rounds Required
- Time Required

Probability of the Maintenance of Suppression:
- % of time suppressed
- Average Rounds Suppressing
- Average Rounds Incapacitating

'Cost' of Suppression:
- % Ammo wastage
- Suppression time per Kg of ammunition

Protection

Probability of Incapacitation

Trade Off Metrics
- Probability of fragments/projectiles hitting specific areas of the body
- Residual energy of the fragments/projectiles

Design Assessments

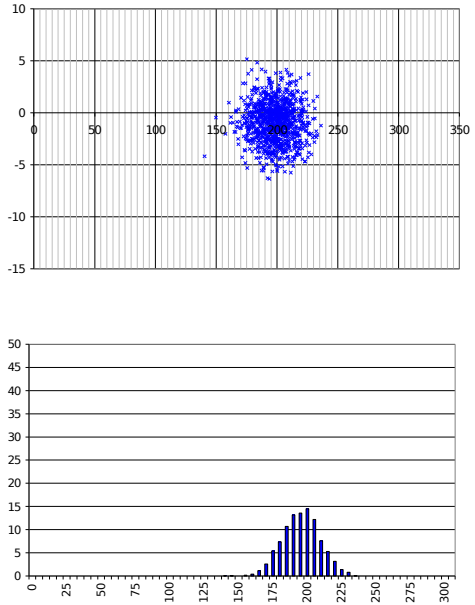
- Multi dimensional analysis of protection system performance including area coverage and protection level

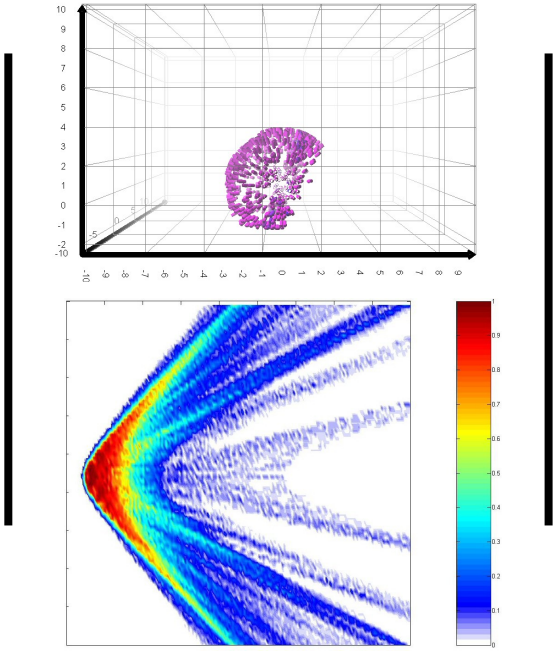
Analysis of System Performance and EffeCtiveness Tool (ASPECT™)

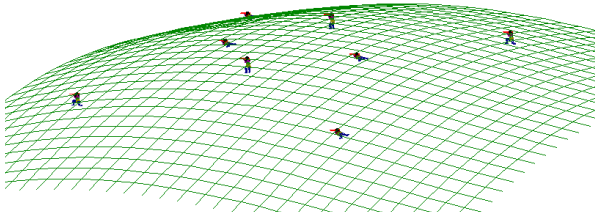
SDE

- Analysis Capabilities of SDE's *ASPECT™* Software Suite

System Error Budgets | Terminal Effects | System Effectiveness





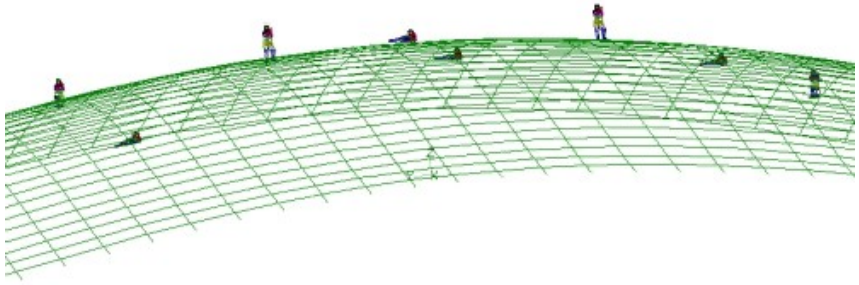


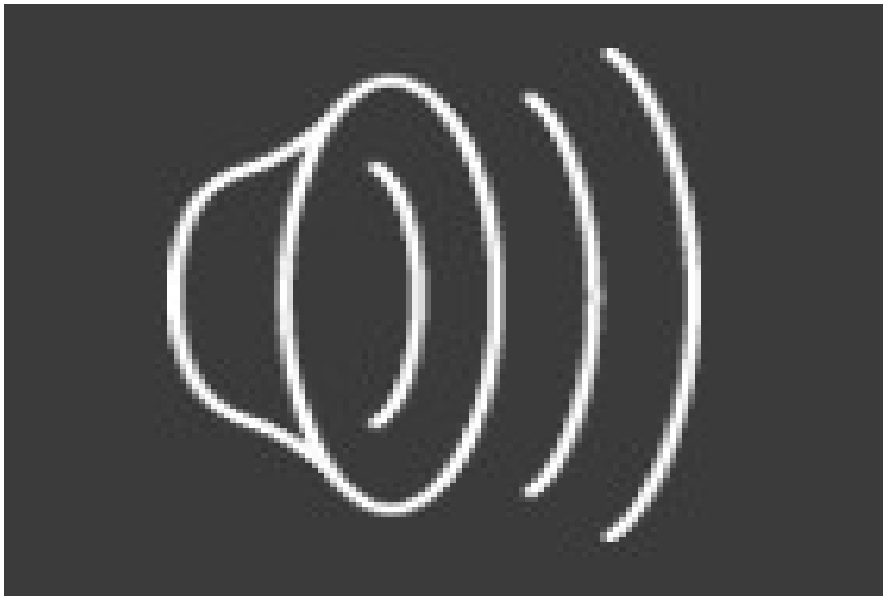
Against static or moving target / target array

Analysis of System Performance and EffeCtiveness Tool (ASPECT™)

SDE

- Pistols
- Rifles
- Machine Guns
- Hand Grenades

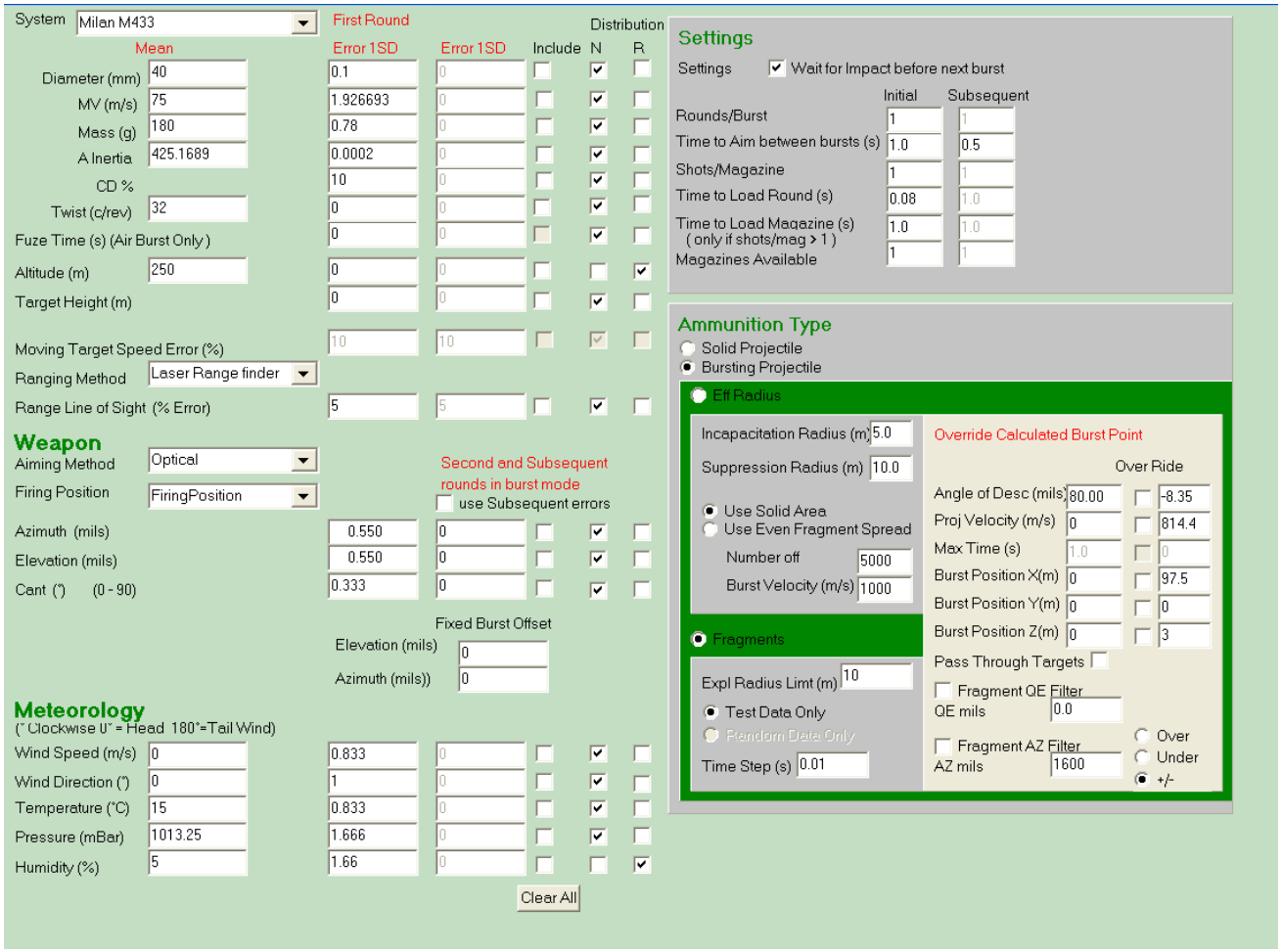




- Mortars
- High and Low Velocity Grenade
- Cannon
- Artillery

System Errors

Error Budgets



Variables

Include

Meteorology

Ammunition

Firer

Weapon

Sight

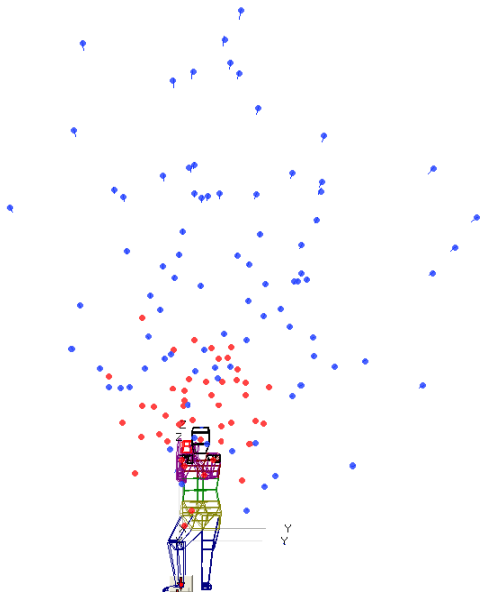
Engagement

Target

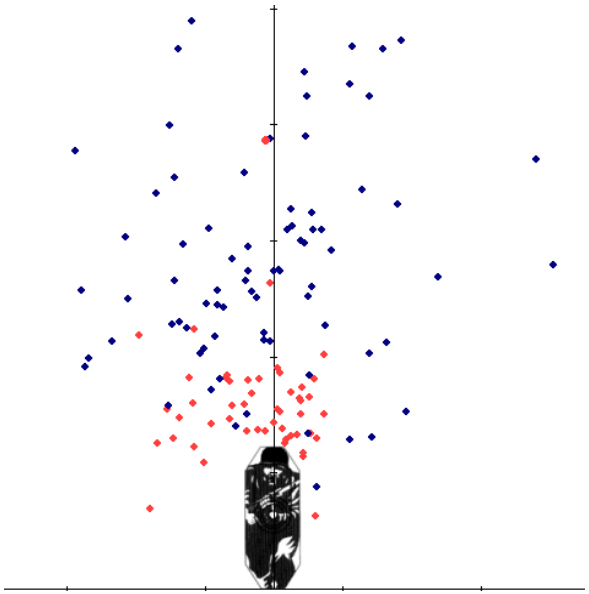
Validation of the LMG model

An Example Test to Confirm the Validity of the ***ASPECT***™ Model

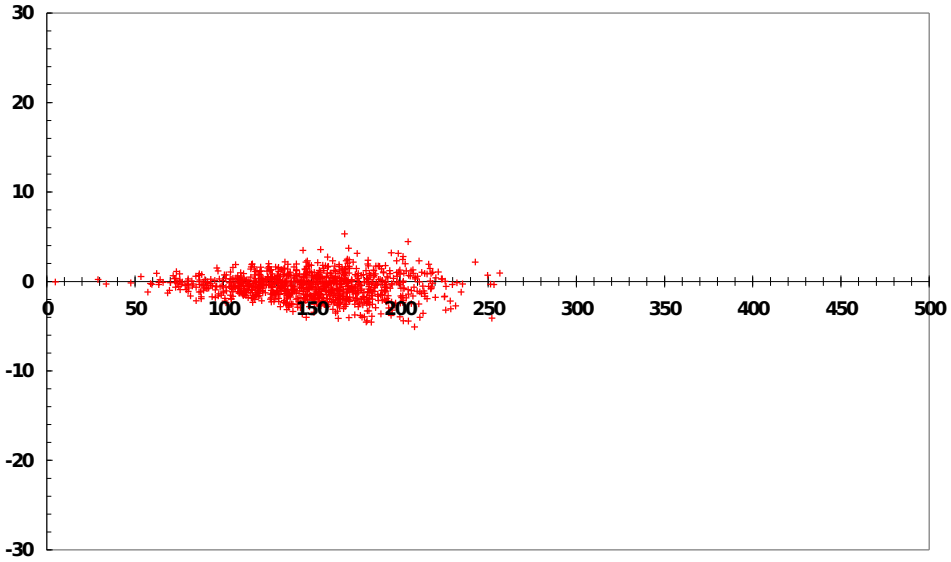
ASPECT™ Output For LMG



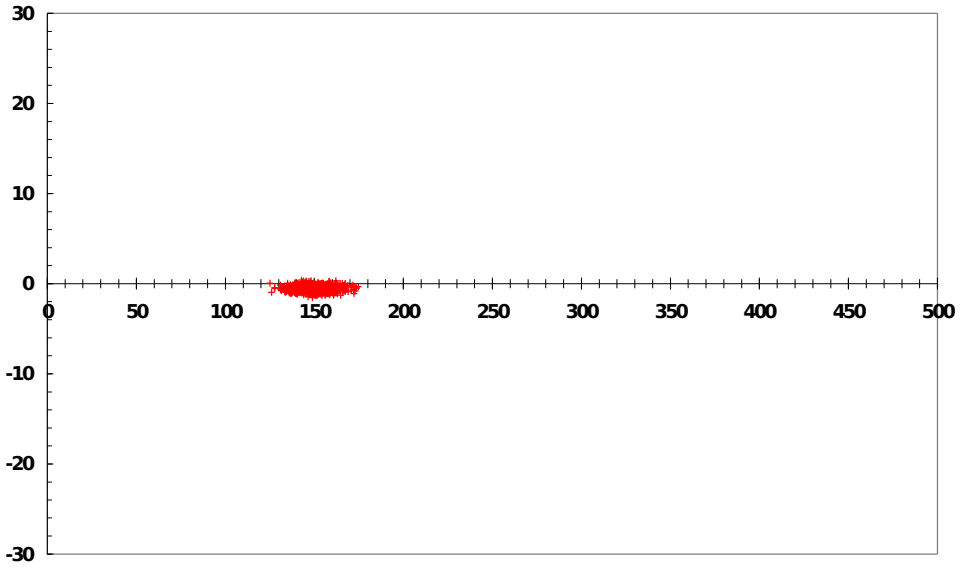
Trials Data For LMG



System Errors

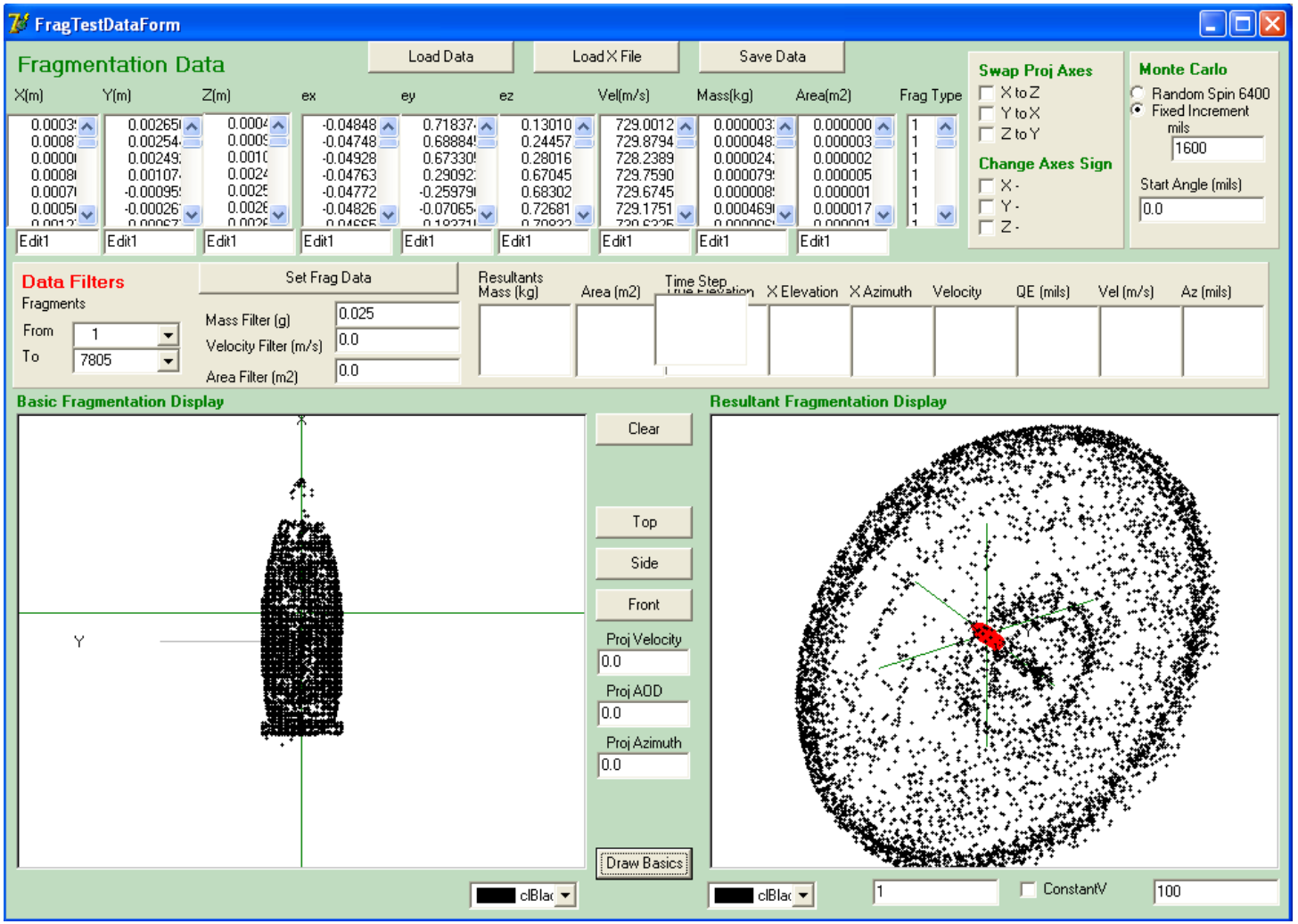


System Errors



Lethality

Fragmentation



Direct Data Import From:

Hydro Code Models (Autodyn & Split-X)

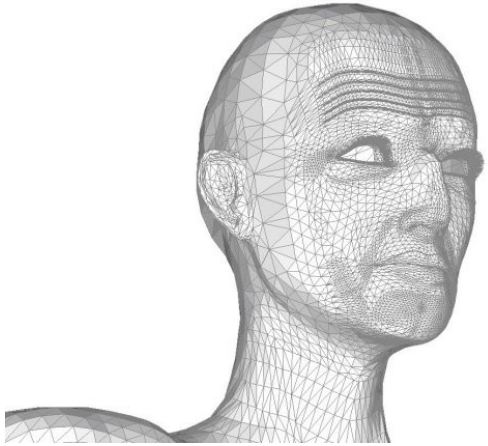
Or

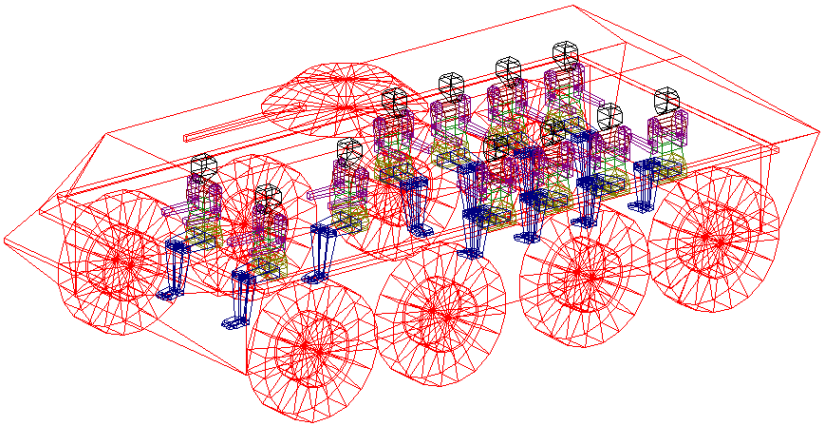
NDIA IS

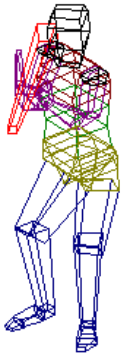
Fragment1.c

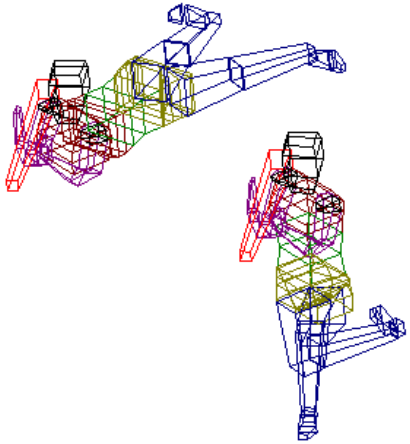
Weapon Effectiveness Target Arrays

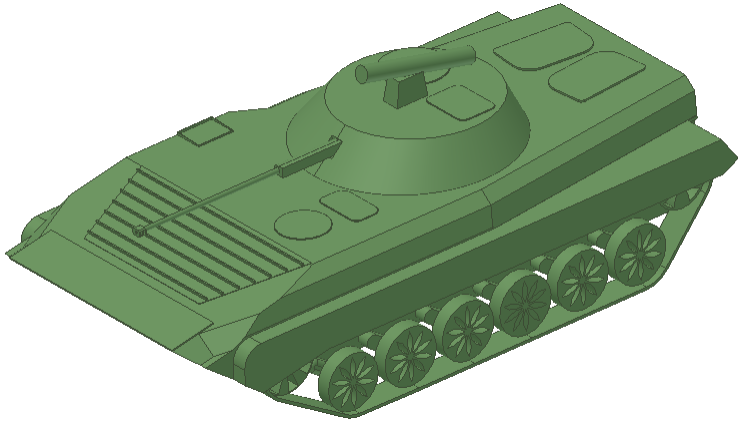
SDE



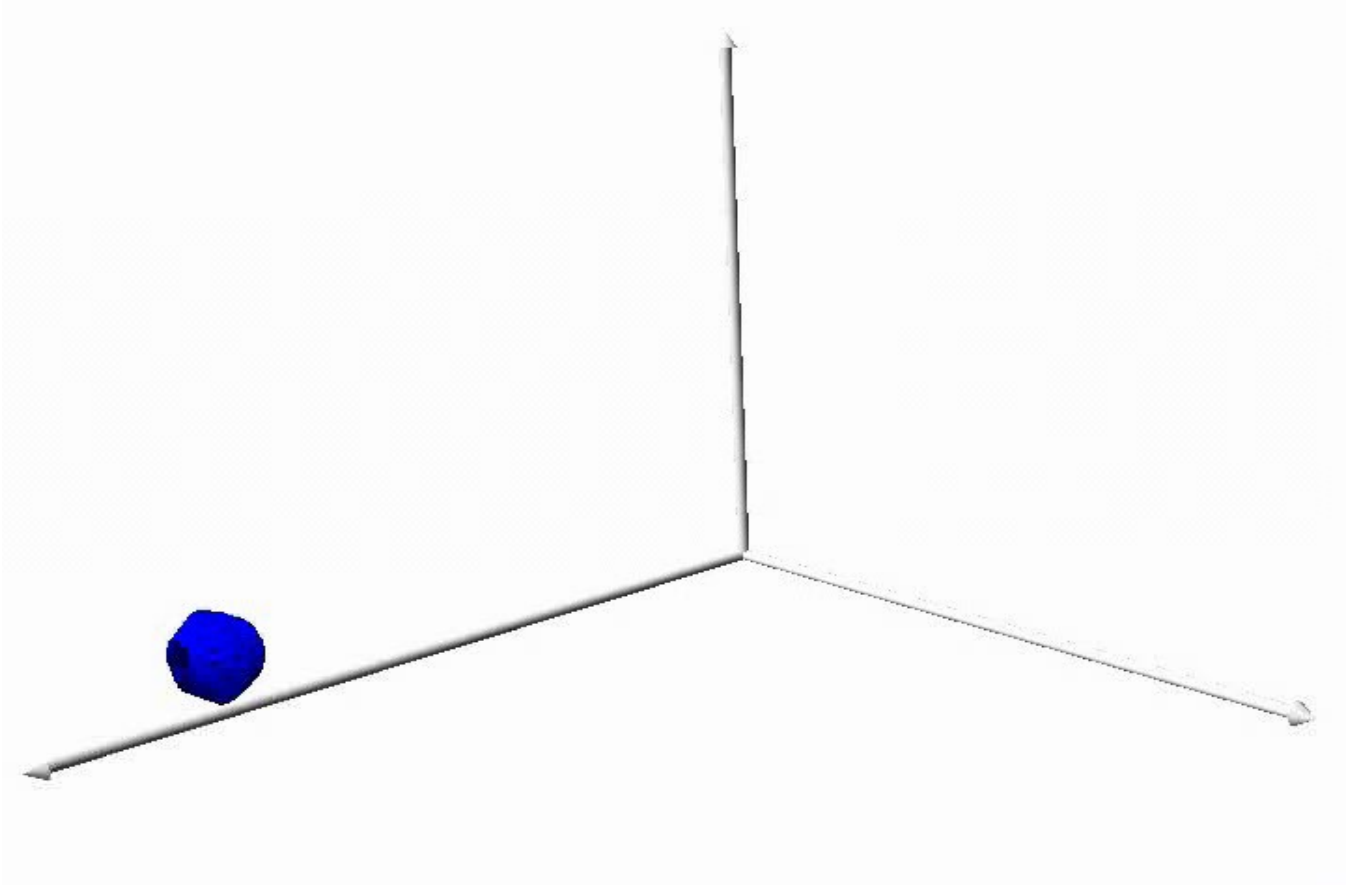






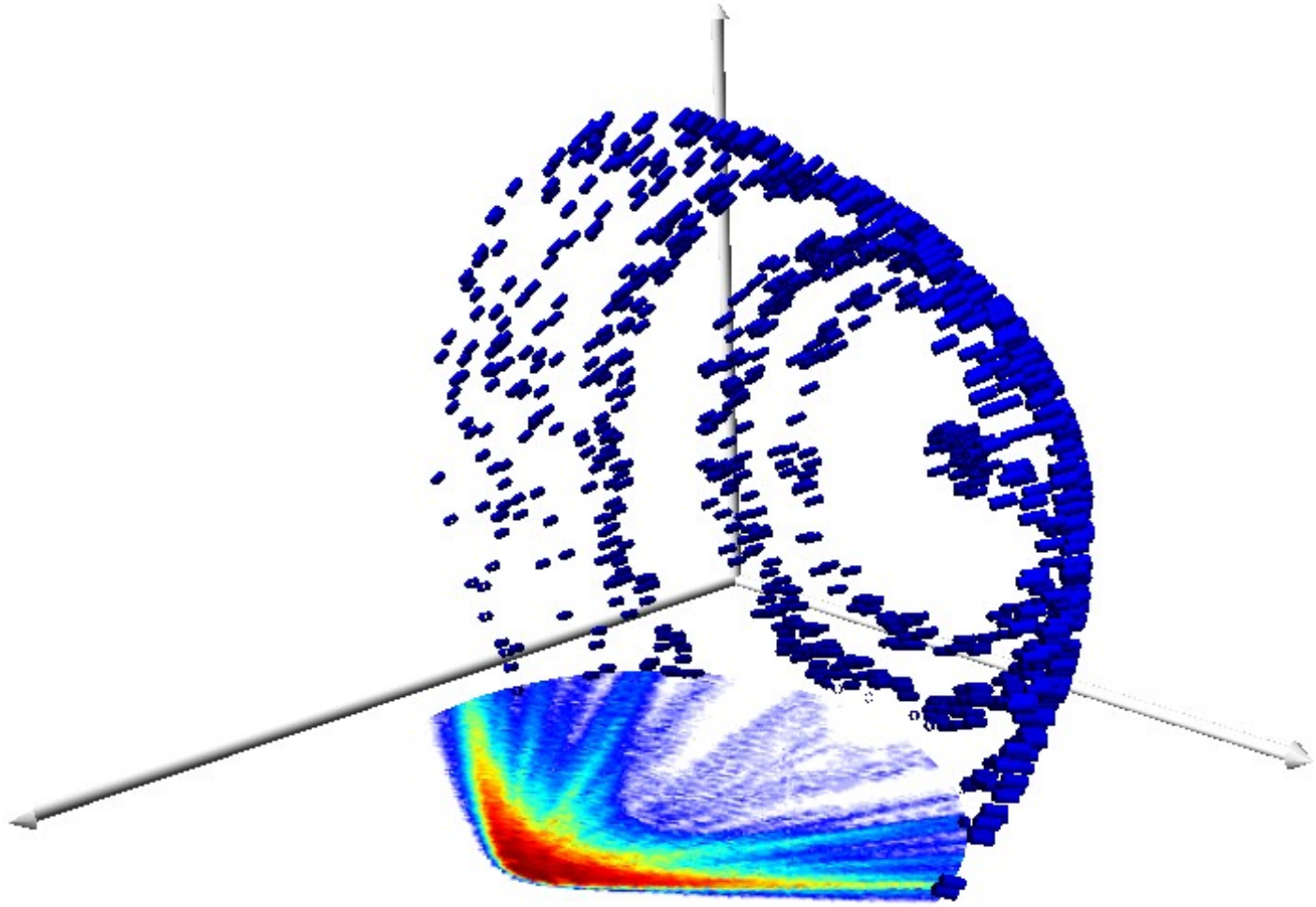


Fragment distribution & Lethality Map

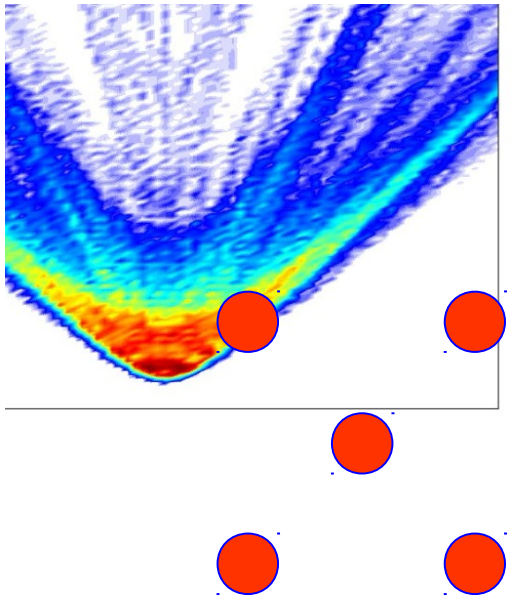


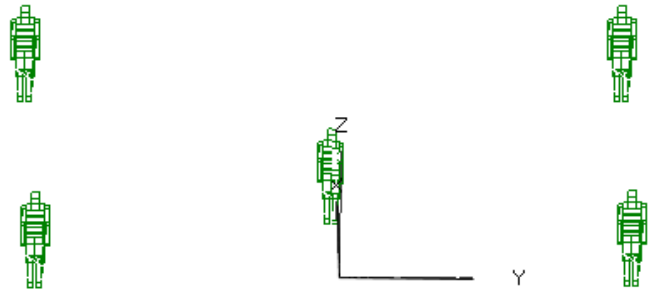
Fragment distribution & Lethality Map

SDE



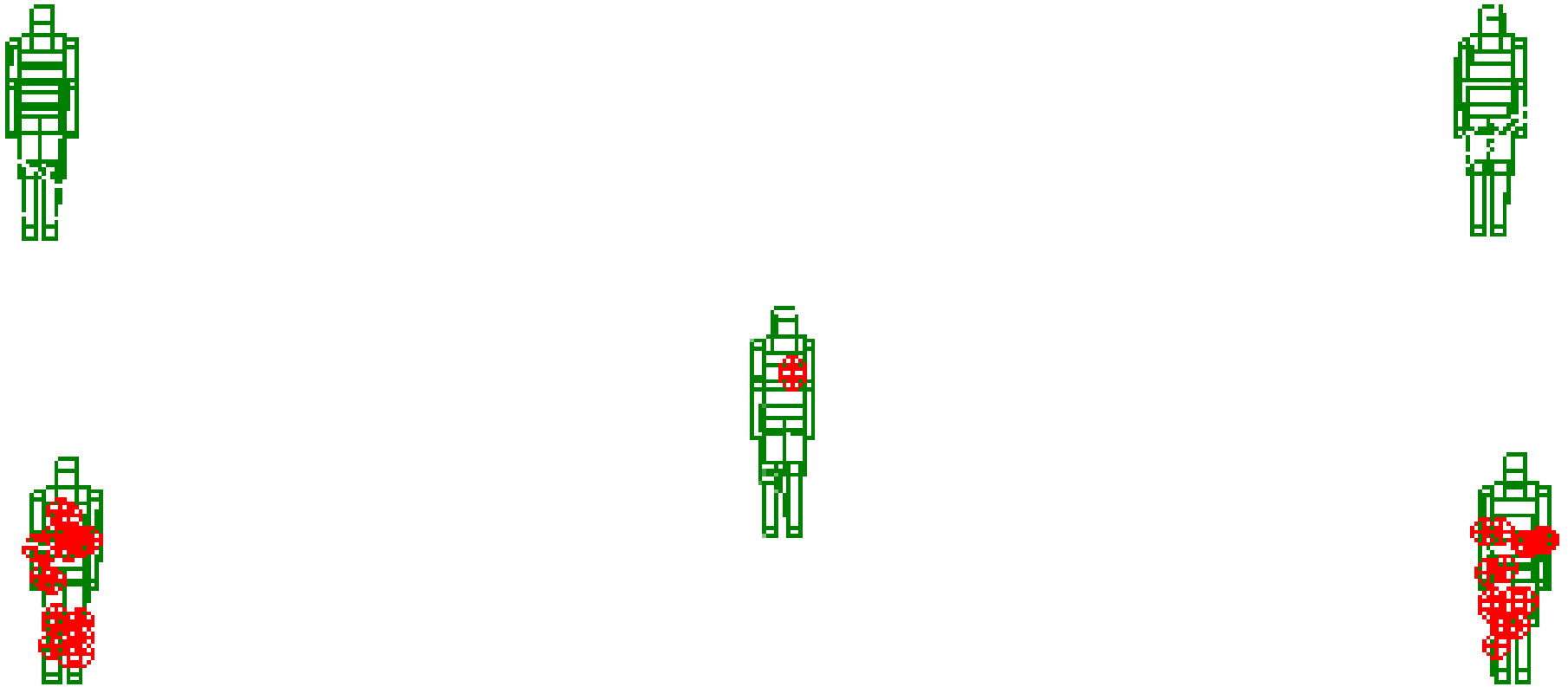
Example – 5 Man Squad



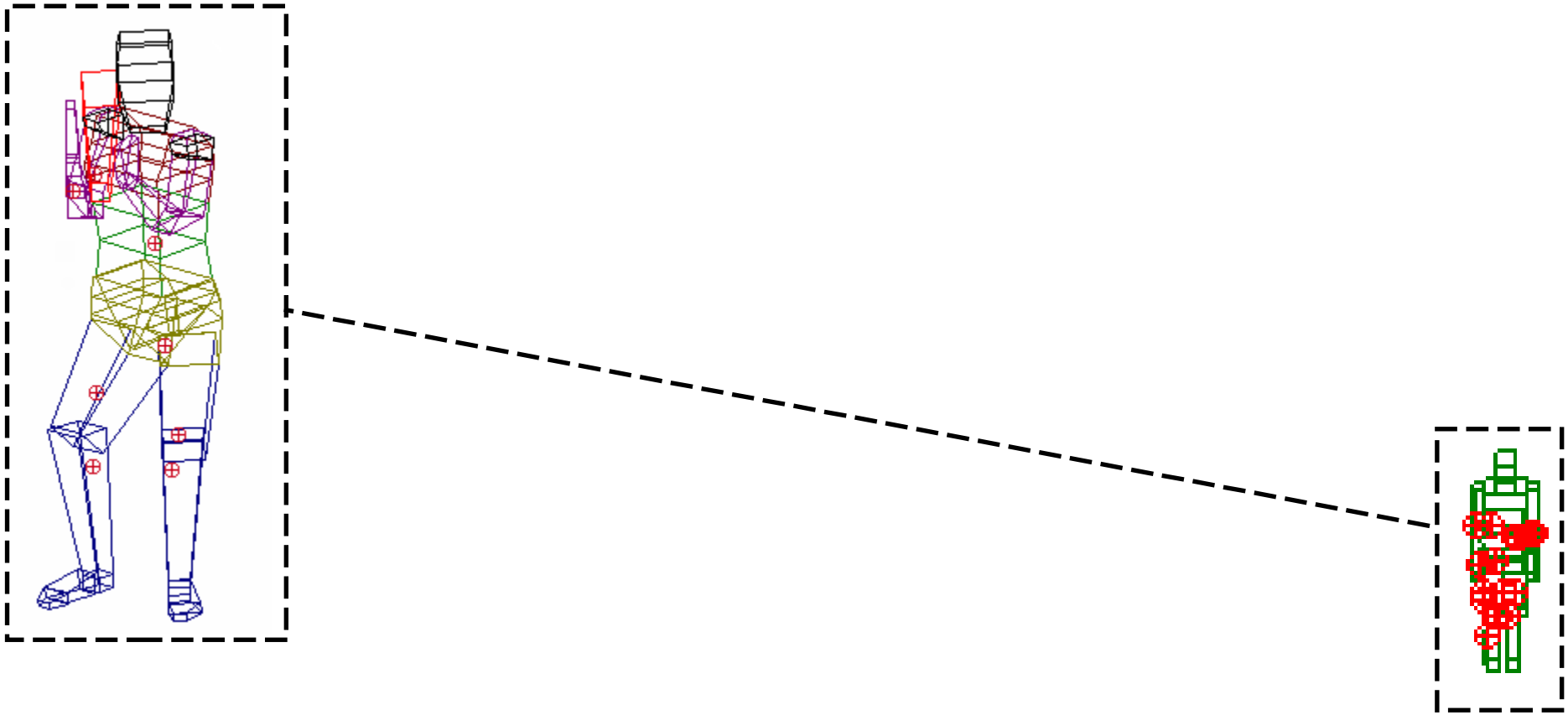


A round is detonated 1m in front of the target area at a height of 3m

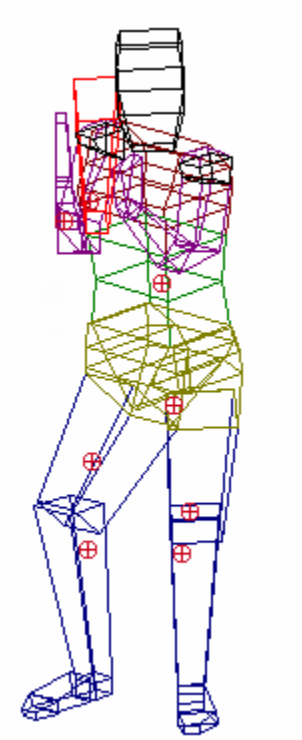
Example - Location of Fragment Impacts



Weapon Effectiveness Example – Single Man Hits



Weapon Effectiveness Example – Single Man Results



Individual Fragment Results

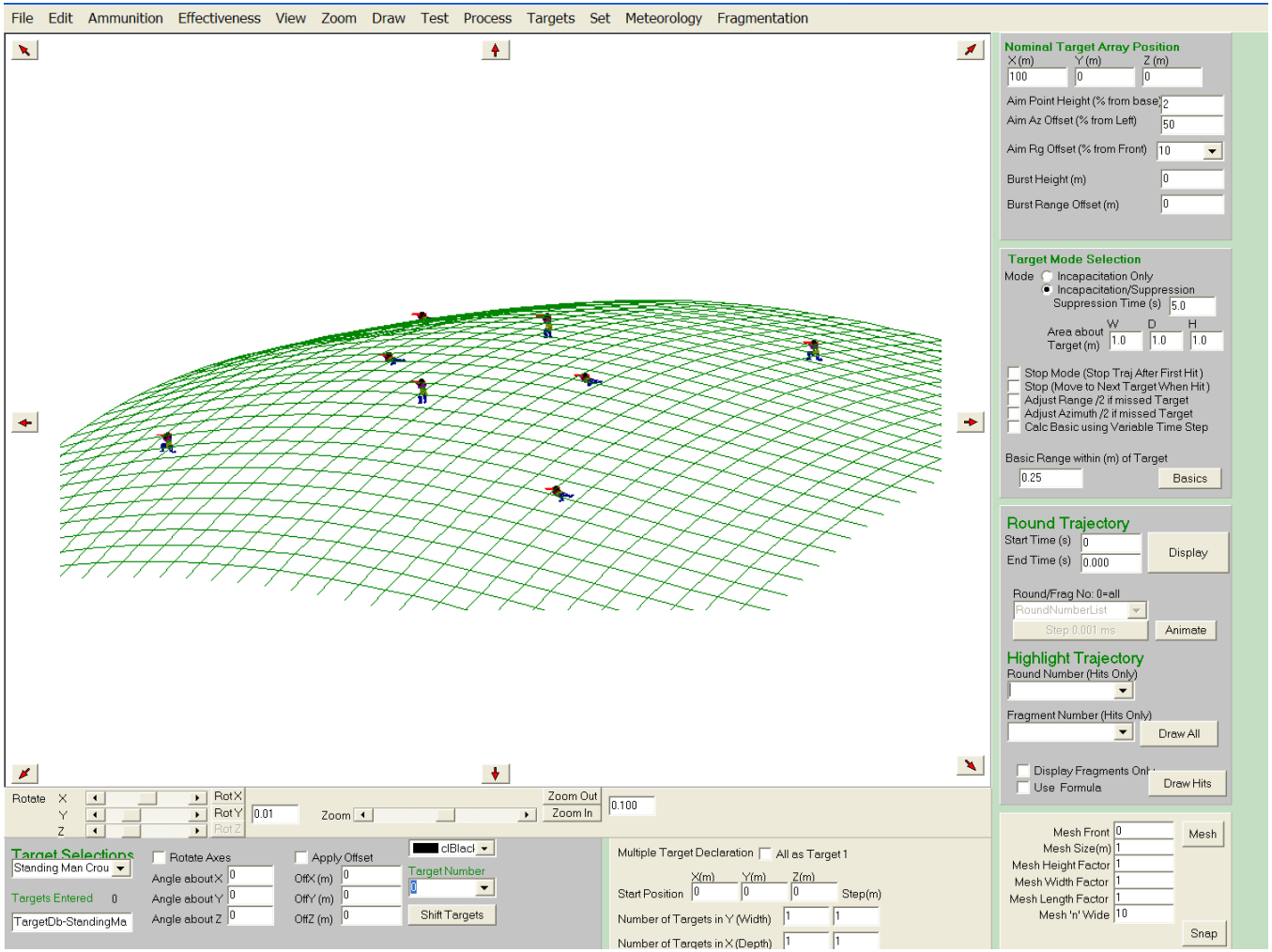
Frag No	Time of flight (sec)	x (m)	y (m)	z (m)	Vel (m/s)	AKE (j)	Body part	Mass (g)	Diameter (mm)	Body part type	Individual P(I/H)
441	0.010857	105.0373	4.93007	0.47771	467.8154	0.4606	7	0.051	3.5233	5	0.0092
446	0.0105	105.1789	4.88091	0.22855 7	524.1856	1.4708	7	0.075	3.8662	5	0.027321
448	0.008974	105.0227	4.98481	0.69450 1	662.6451	9.0647	5	0.154	4.6277	5	0.133044
454	0.01226	105.0104	5.07578	1.16852 8	373.0807	0.0286	3	0.030	3.0819	3	0
552	0.008379	105.1424	4.85669	0.55594 5	749.5075	27.472	5	0.278	5.3345	5	0.287019
554	0.007577	105.142	4.85248	0.61514 3	922.1483	265.80	5	1.547	8.1906	5	0.62521
555	0.007449	105.0628	4.80789	0.90192	937.587	303.72	1	1	8.7709	6	0.511299
556	0.009751	105.053	4.79439 5	1.22053 5	549.668 0	1.9328 8	1	6.99796	3.9153	6	0.090384

Target Results

x (m)	y (m)	z (m)	No of hits	total frag mass (g)	**total P(I/H)**
4.794395	1.220535	549.6683	1.93288	6.99796	**0.90075**

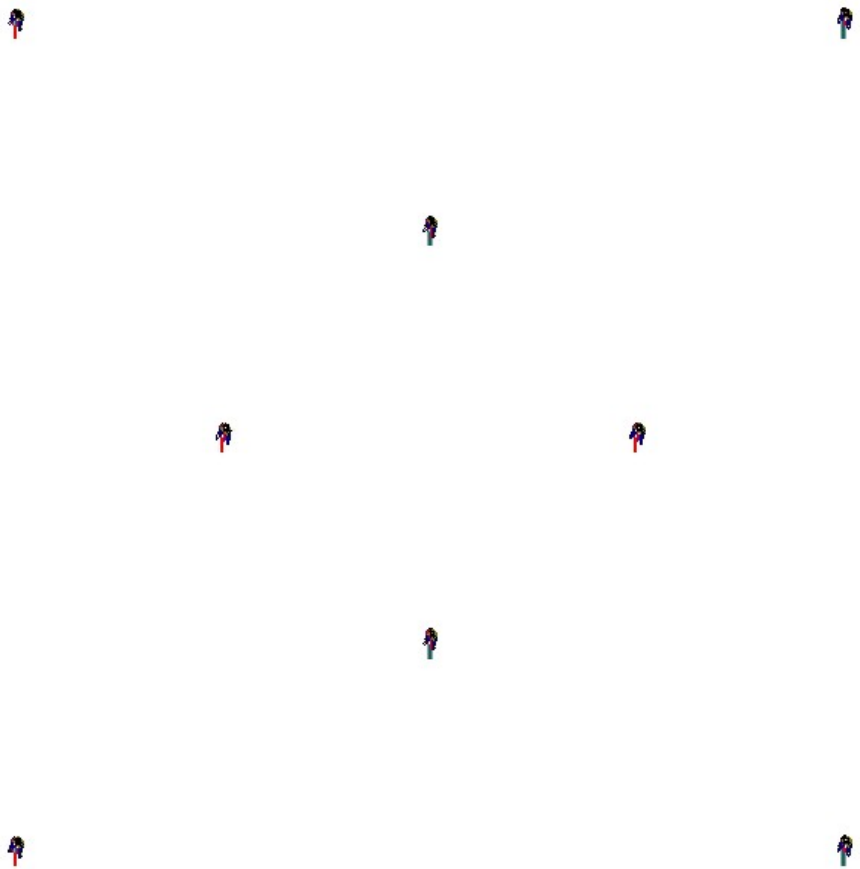
System Effectiveness

The Target


File Edit Ammunition Effectiveness View Zoom Draw Test Process Targets Set Meteorology Fragmentation
Nominal Target Array Position
X (m) Y (m) Z (m)
100 0 0
Aim Point Height (% from base) 2
Aim Az Offset (% from Left) 50
Aim Rg Offset (% from Front) 10
Burst Height (m) 0
Burst Range Offset (m) 0
Target Mode Selection
Mode Incapacitation Only
Incapacitation/Suppression
Suppression Time (s) 5.0
Area about Target (m) W 1.0 D 1.0 H 1.0
Stop Mode (Stop Traj After First Hit)
Stop (Move to Next Target When Hit)
Adjust Range /2 if missed Target
Adjust Azimuth /2 if missed Target
Calc Basic using Variable Time Step
Basic Range within (m) of Target
0.25
Basics
Round Trajectory
Start Time (s) 0
End Time (s) 0.000
Display
Round/Frag No: 0=all
RoundNumberList
Step 0.001 ms
Animate
Highlight Trajectory
Round Number (Hits Only)
Fragment Number (Hits Only)
Draw All
Display Fragments Only
Use Formula
Draw Hits
Rotate X Y Z
Rot X Rot Y Rot Z
0.01
Zoom
Zoom Out
Zoom In
0.100
Target Selections
Standing Man Crou
Targets Entered 0
TargetDb-StandingMa
Rotate Axes
Angle about X 0
Angle about Y 0
Angle about Z 0
Apply Offset
OffX (m) 0
OffY (m) 0
OffZ (m) 0
clBlack
Target Number 0
Shift Targets
Multiple Target Declaration All as Target 1
X(m) Y(m) Z(m)
Start Position 0 0 0 Step(m)
Number of Targets in Y (Width) 1 1
Number of Targets in X (Depth) 1 1
Mesh Front 0
Mesh Size(m) 1
Mesh Height Factor 1
Mesh Width Factor 1
Mesh Length Factor 1
Mesh 'n' Wide 10
Mesh
Snap

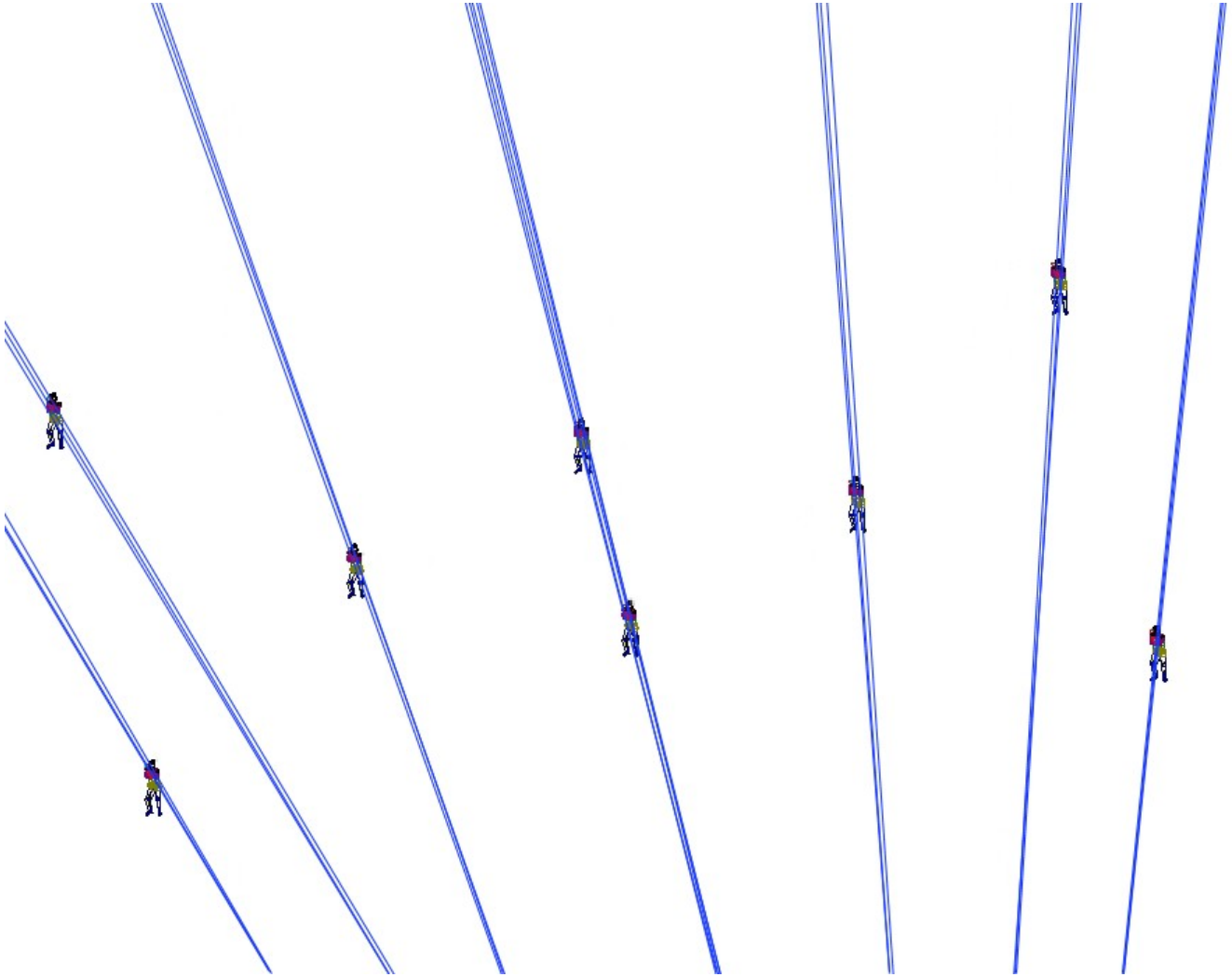
Effectiveness of Weapon Systems

SDE

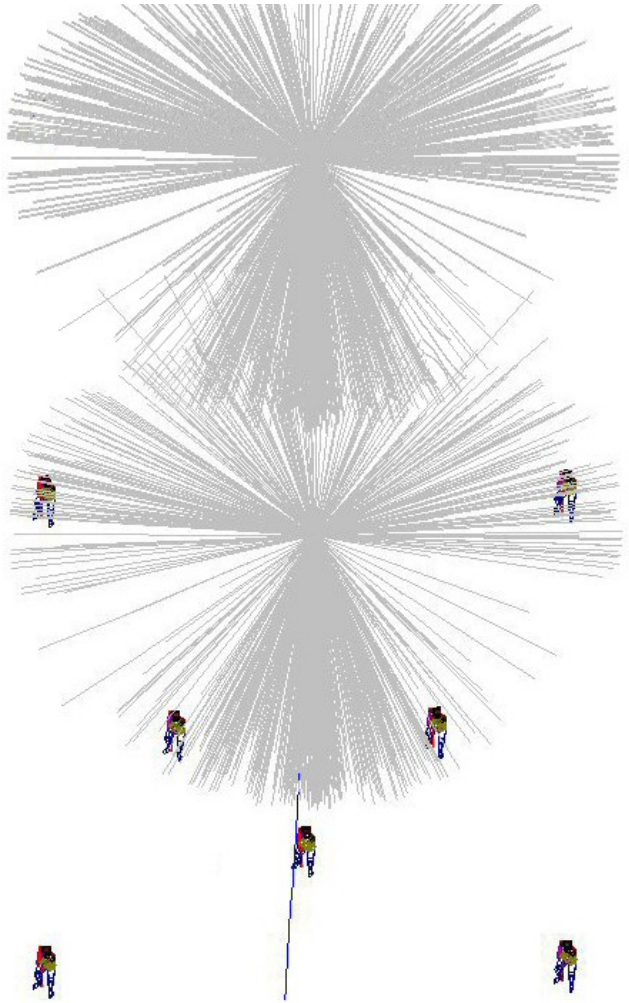


Effectiveness of Weapon Systems Direct Fire

SDE



Effectiveness of Weapon Systems
Bursting Munitions



ASPECT™ **Outputs**

- Outputs of *ASPECT™* Include:
  - Number of incapacitations/suppressions for a given ammo load
  - Percentage of ammunition wastage
  - Probability of first round hit
  - Time to incapacitate/suppress one or more targets
  - Probability of incapacitation of bursting munitions

Soldier System Assessment Range

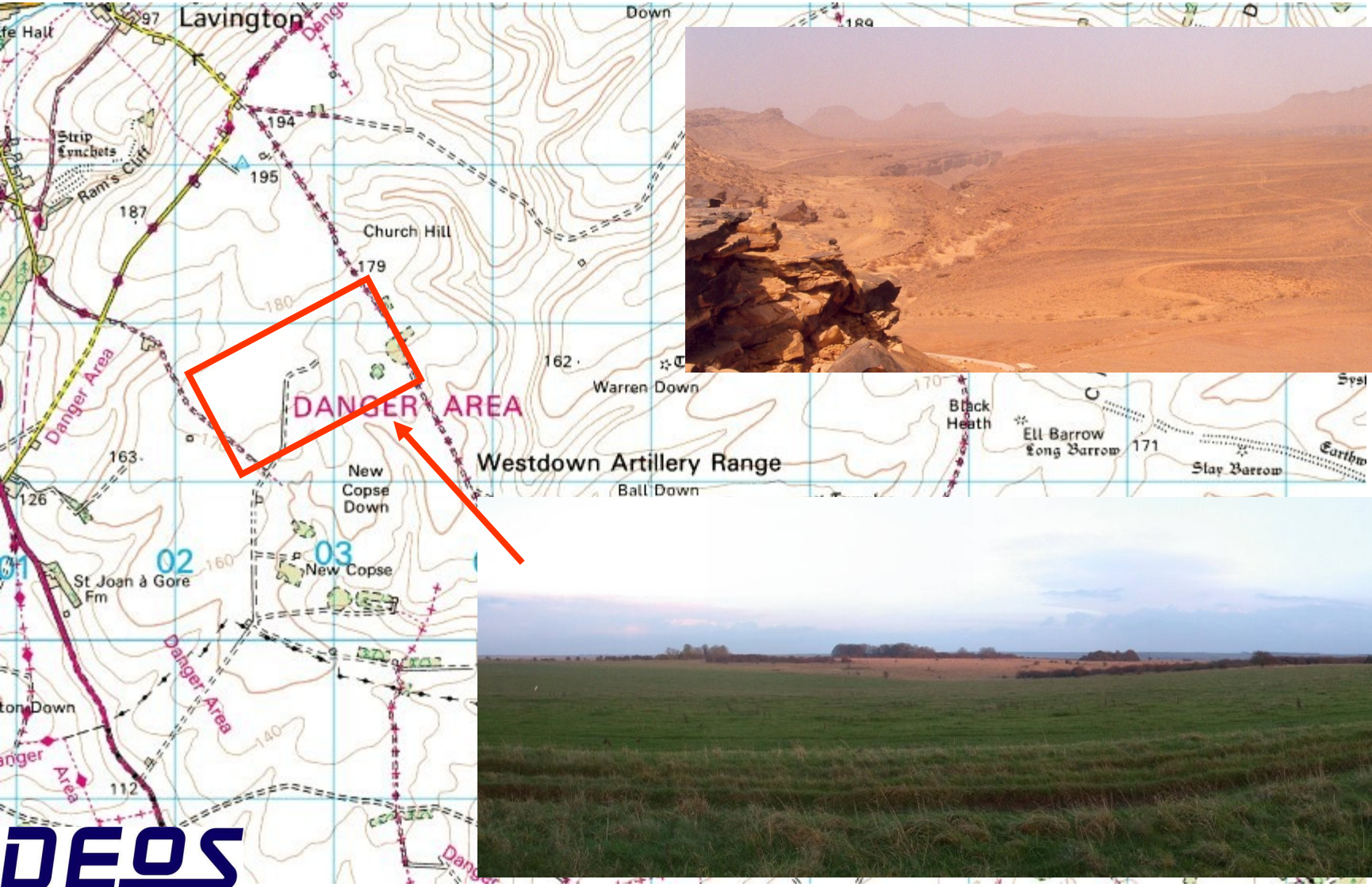
SDE

Soldier System Assessment Range

*An initiative by **System Design Evaluation (SDE) Ltd** and **Cranfield University** to provide a fully instrumented range for technical, technical User and User trials of small and medium calibre weapon systems and their ancillaries in a realistic tactical environment.*

The purpose being to generate qualitative data in order to allow the objective and auditable assessment of individual item, soldier and system performance

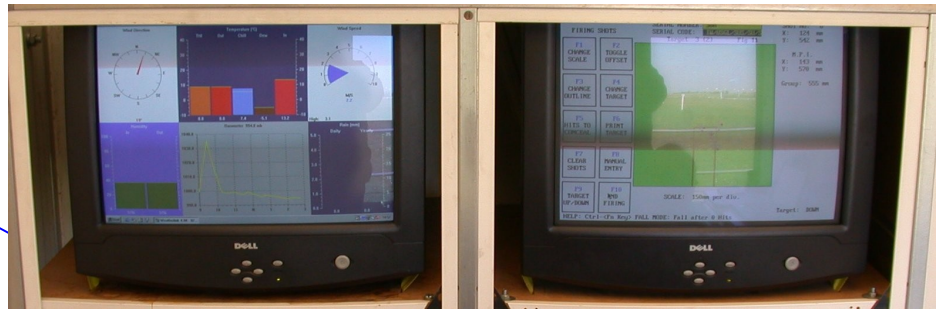
COTEC and Elsewhere



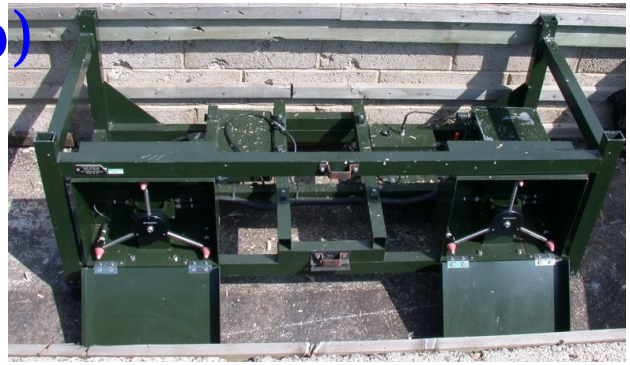
The Range Equipment

The System

Optical Target



Moving Target (Acoustic Pop Up)

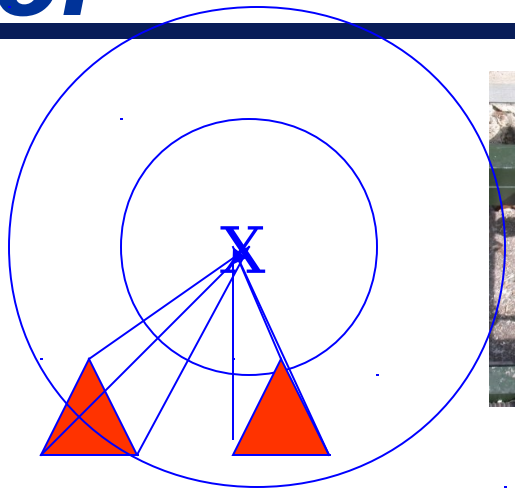


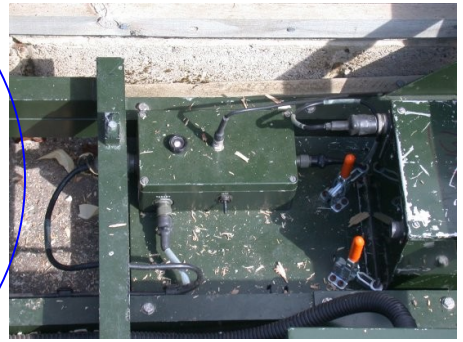
Acoustic Target

Trailer Mounted Base Sta

+ Trenches !

Acoustic Shot Position Indicator



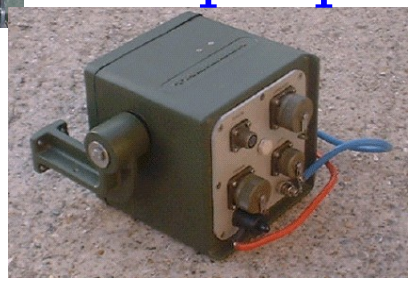


Transceiver

Delta Transducer Array

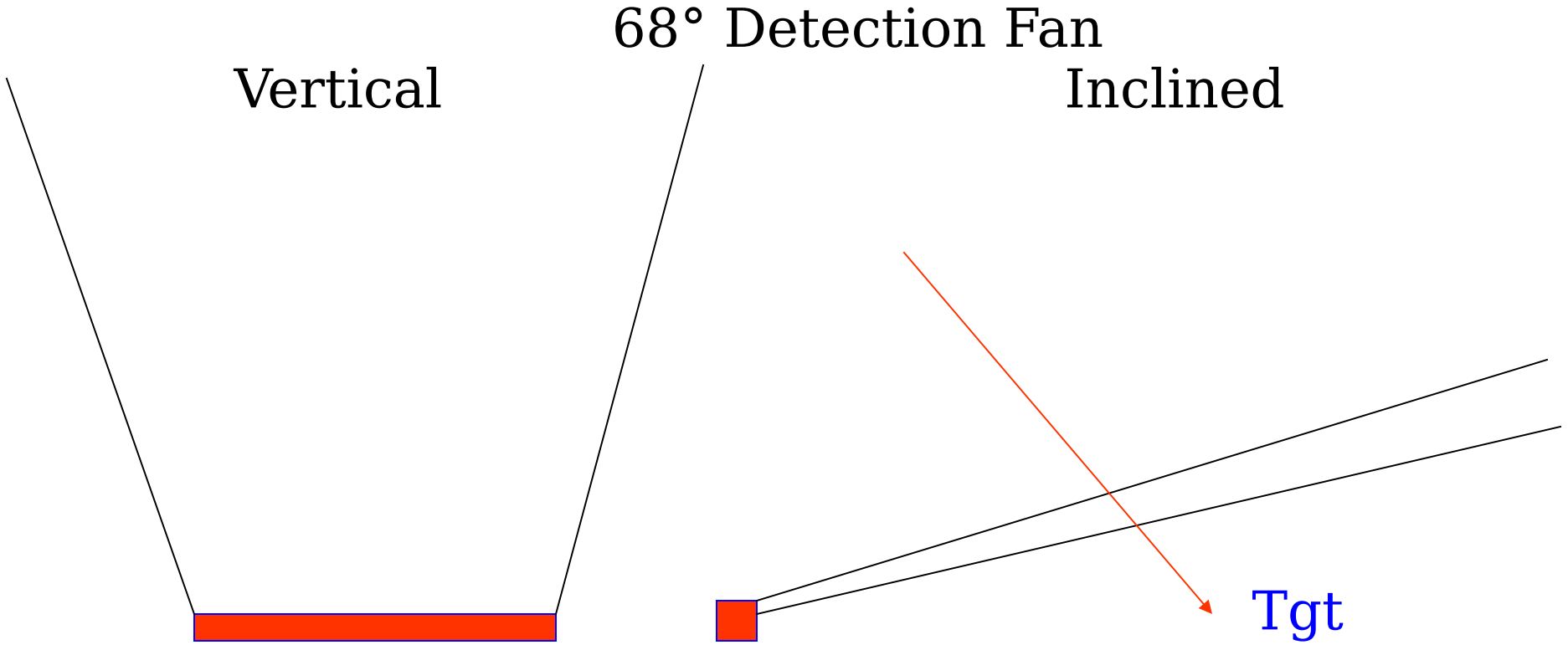
Computer

Pop Up

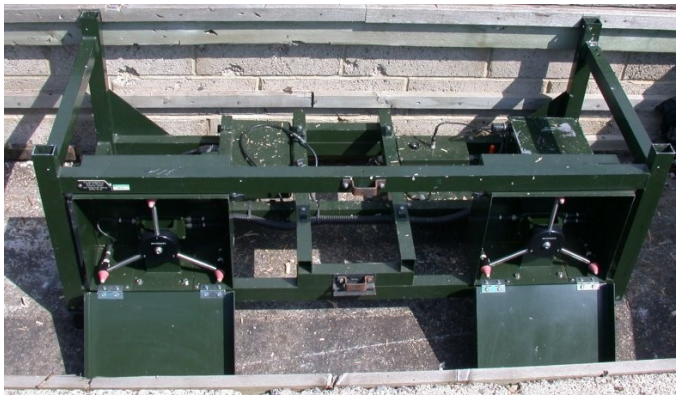


FFSPI

FFSPI Optical Target

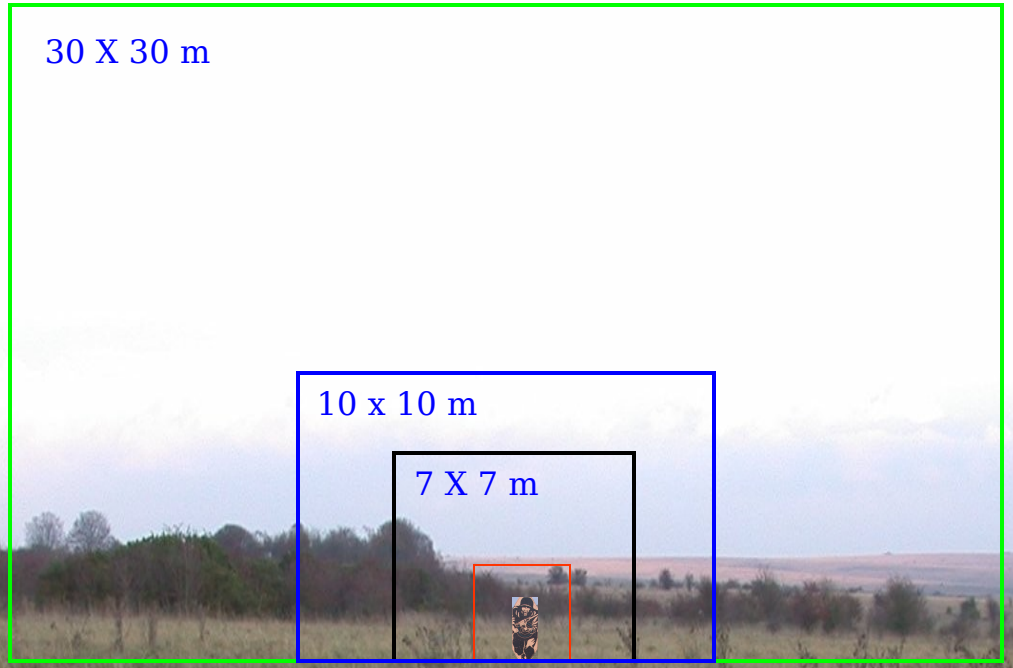


Mover

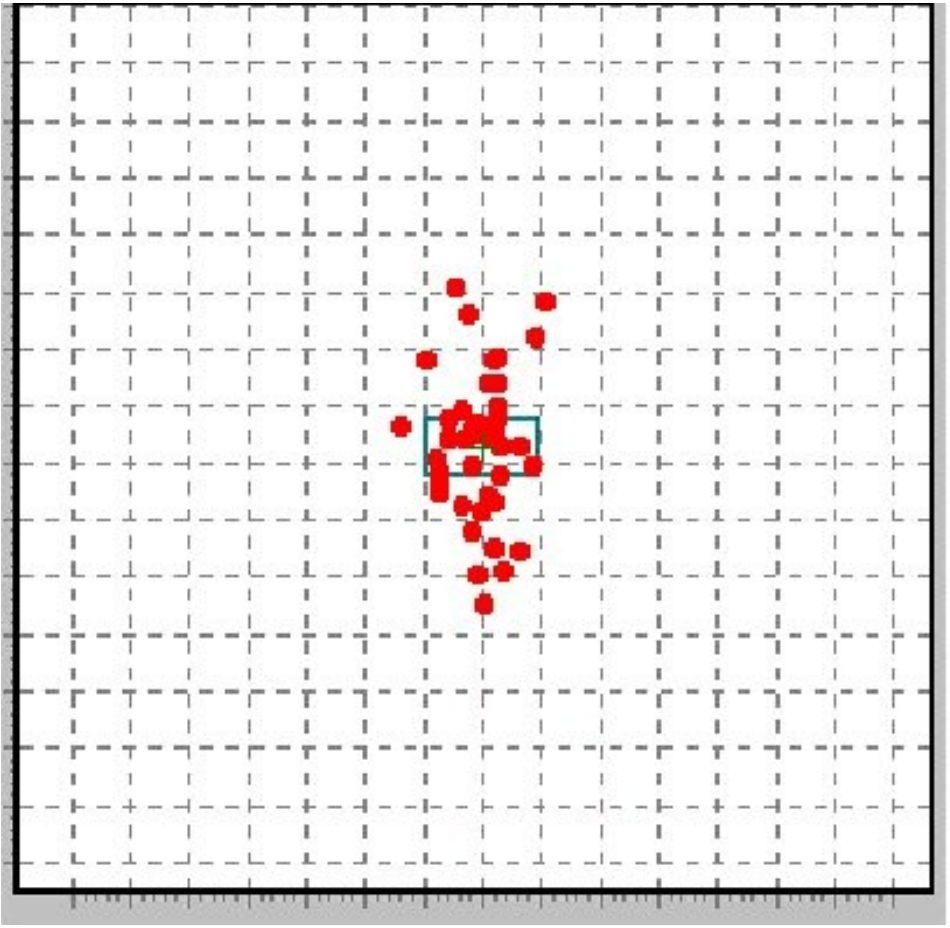


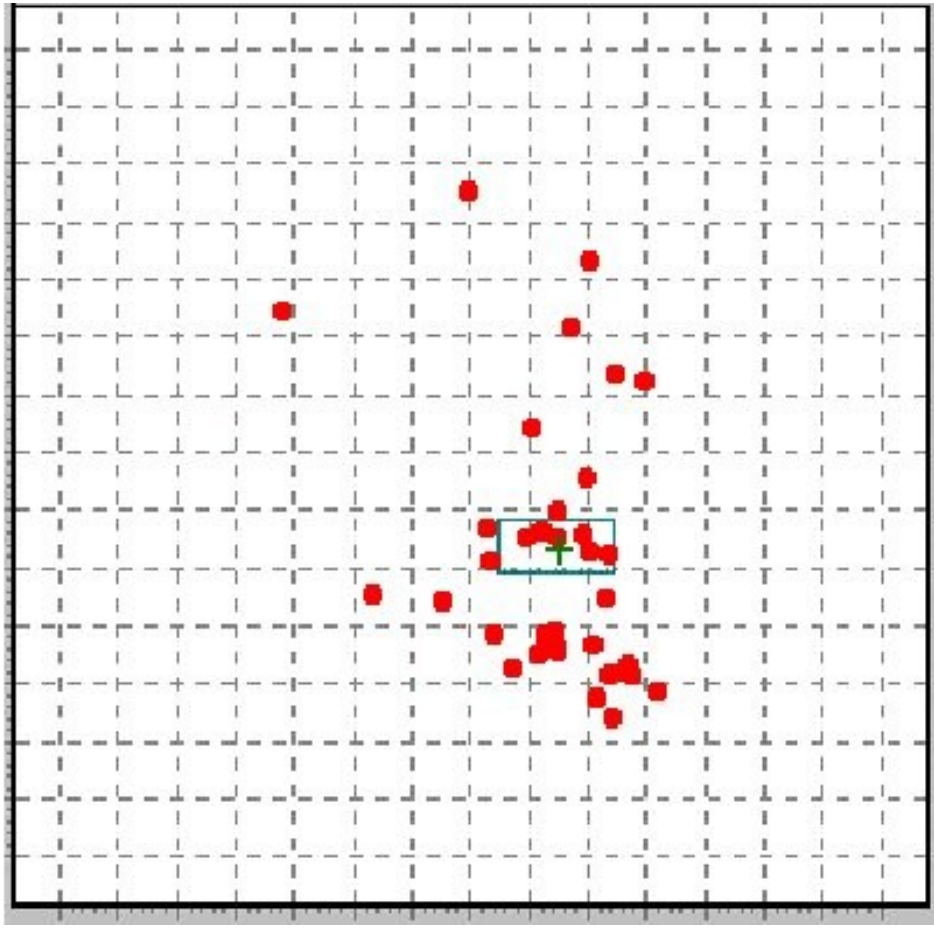
Range simulation

Detection, Accurate Detection & Suppression Areas



Comparative Assessment





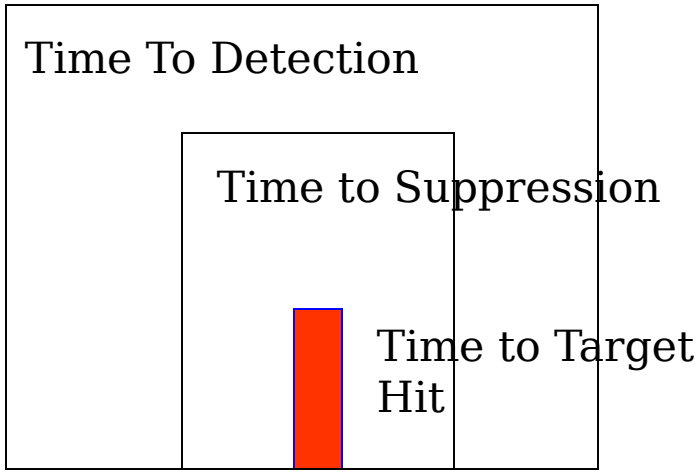
Data & Basic Statistics

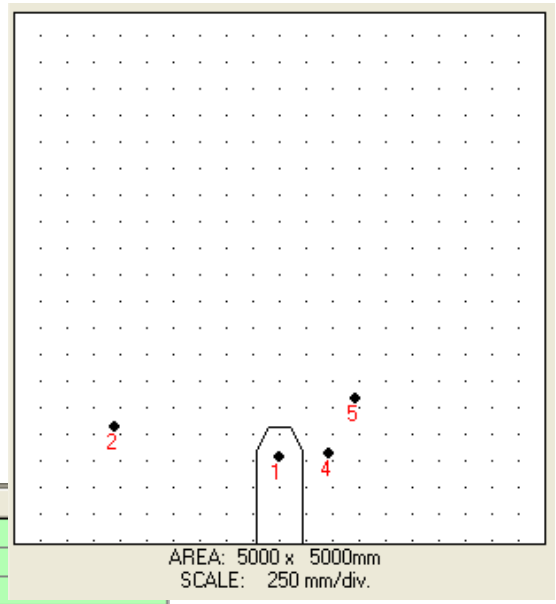
True X &Y Cartesian co-ordinate data

Time of each shot (UTC & Computer)

Statistics:

- MPI
- Group Rectangle (mm)
- X & Y SD (mm and mils)
- Extreme spread (mm)
- Mean Radius (mm and mils)
- Group SD (mm and mils)
- Probabilities of a Hit, Suppression & Incapacitation





	ShotNo	Dropped	X	Y	TimeStamp	UTC	UTCV	Date	Remarks
	1	☐	0	43	5208659	36959037	0	08/07/2004 10:15:59	
	2	☐	-1546	321	5213306	36963684	0	08/07/2004 10:16:03	
	3	☐	612	-1678	5216561	36966939	0	08/07/2004 10:16:06	
	4	☐	474	69	160200	77286371	0	31/08/2004 21:28:06	

Access™ Database Data

SDE

Trial Subject

- Firers Name
- Rank
- Service/Regimental No
- Left of Right Handed
- Eye Bias
- Spectacle use
- Length of Service
- Height
- Weight
- Age
- Weapon Experience

Group Shot Data

A unique serial no for each group fired identifying:

- The firer
- Firer's position
- Weapon
- Mode of fire
- Ammunition
- Range
- The target

Clothing & Eqpt

- Firer's dress and equipment details

Meteorological

When linked to an automatic weather station

- temperature
- wind speed
- wind direction relative to line of fire
- atmospheric pressure
- relative humidity
- rainfall

Weapon

- Model
- Serial No
- Barrel History

Ammunition

- Nature
- Lot no

Sights

- Type
- Model
- Serial no

Combined Analysis (M249 Trial)

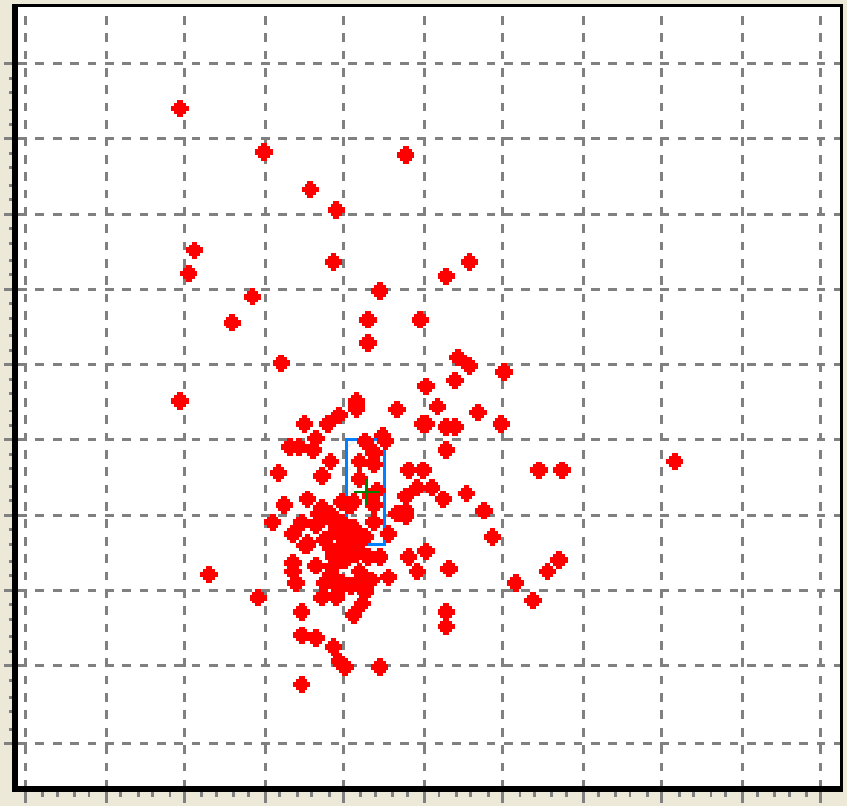
SDE

Load / Save Data | Load Combined | Shot Statistics

100 m

	(X)	(Y)
M.P.I.	296.35	1297.92
Group Rectangle (mm)	2356.94	3356.81
Std. Deviation (mm)	842.68	1139.16
Std. Deviation (mils)	8.58	11.60

Group (mm)	3837.75
Mean Radius (mm)	1131.31
Mean Radius (mils)	11.52
Group S.D. (mm)	1001.95
Group S.D. (mils)	10.21
Probability of Hit	1.87%



Scale: 1000mm per division

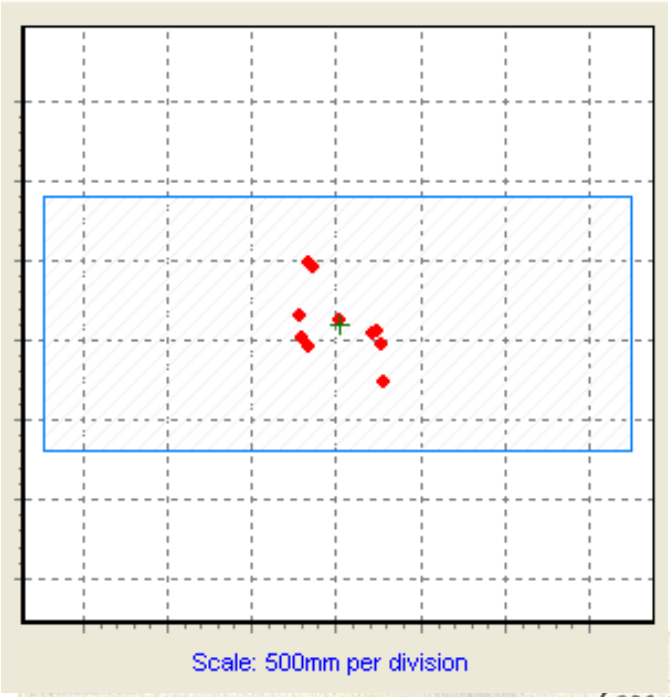
161 Good Shots, 0 Dropped

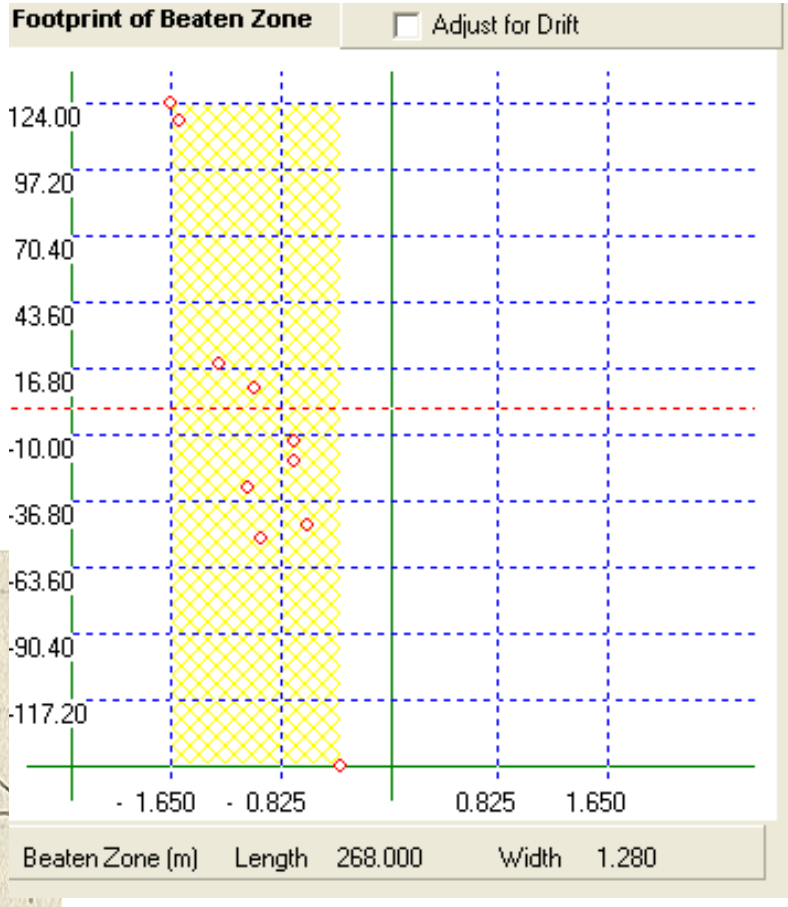
Print: Graph | Preview | Data

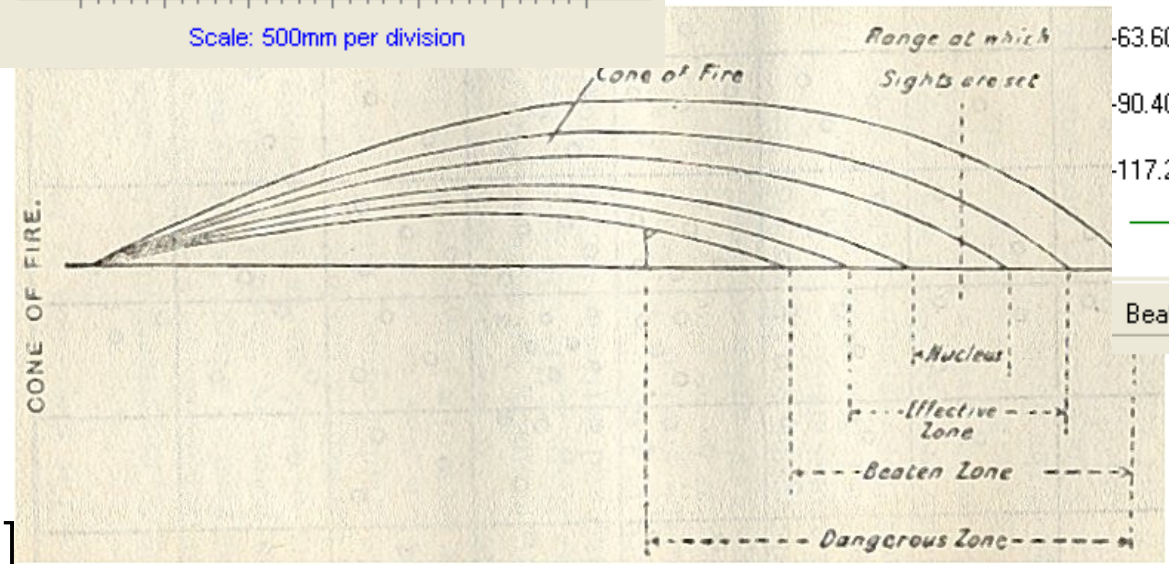
Chart | Chart Settings

N

Comparison of Vertical and Horizontal Data



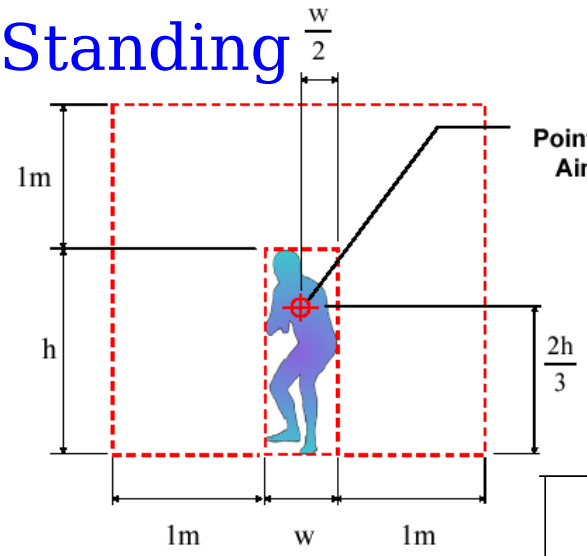




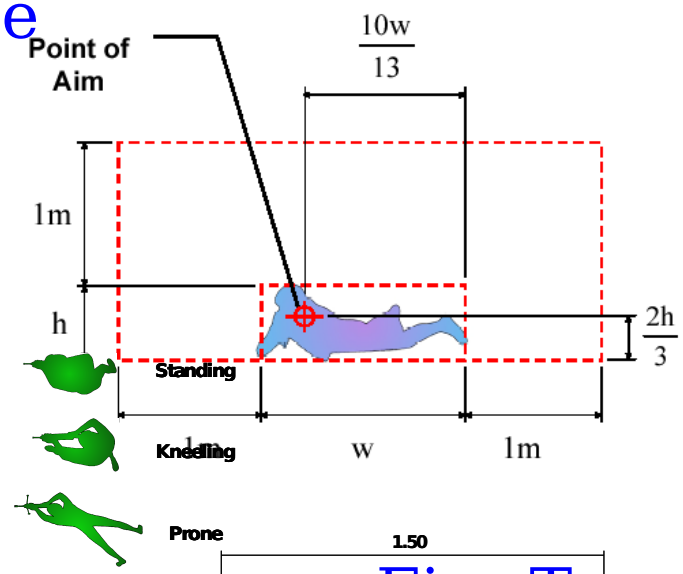
Target Sets
Incapacitation and Suppression

SDE

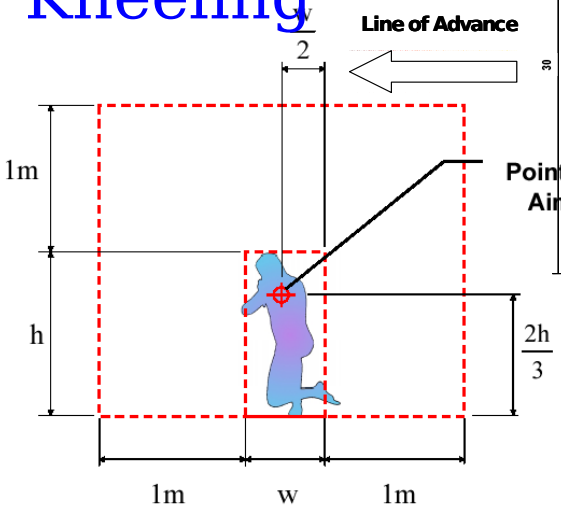
Standing



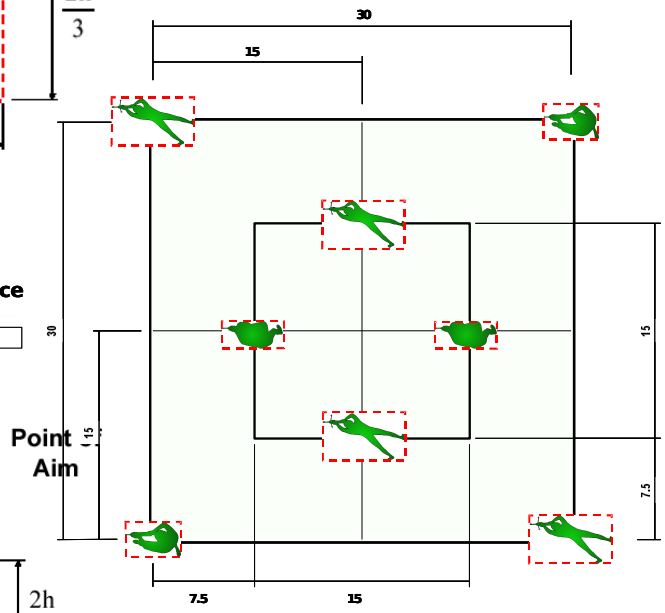
Prone



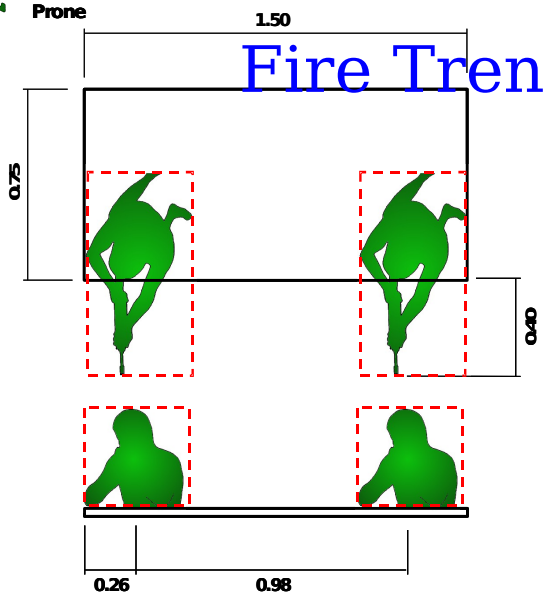
Kneeling



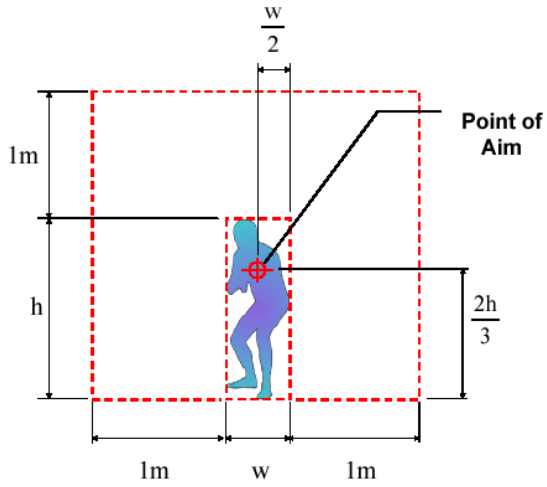
Area

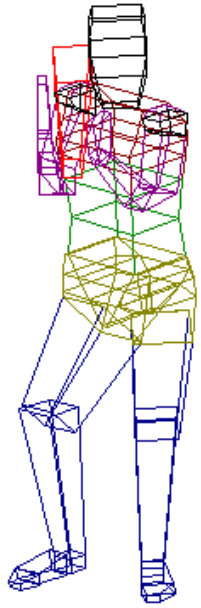


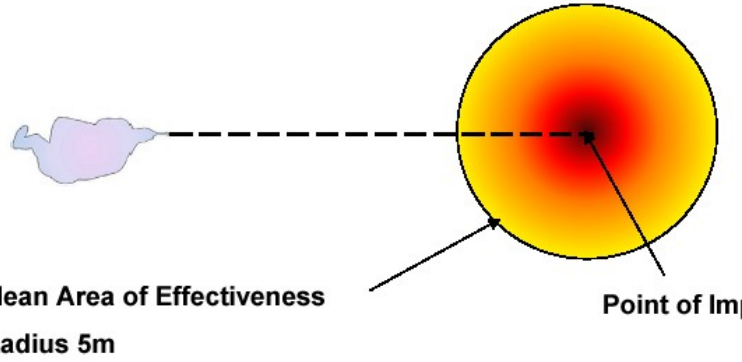
Fire Trench



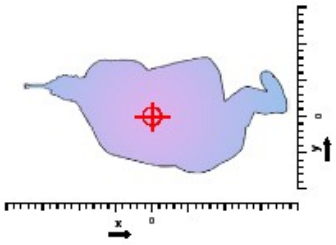
Incapacitation and Suppression Effect Choices

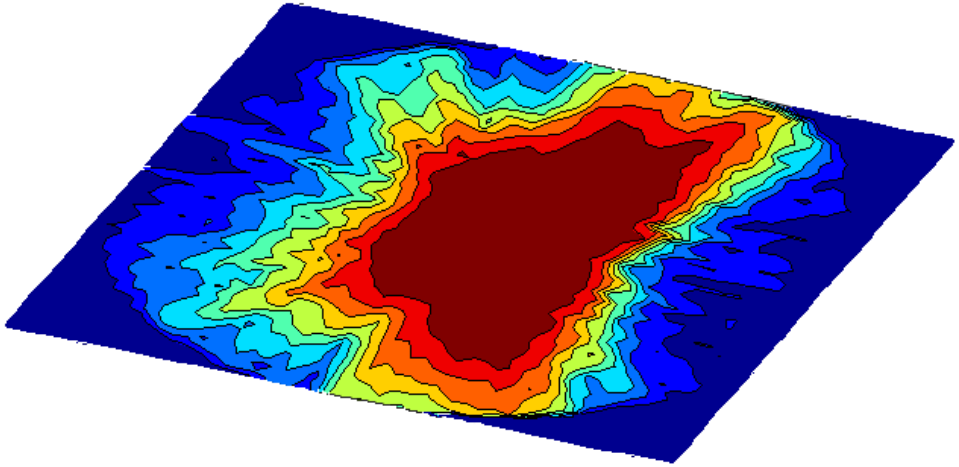






Standing Man





Metrics

Based on either individual or group performance (if required with (a) specific discriminator/s) the powerful database tool can produce the following metrics:

- **Probabilities** in either the vertical or horizontal plane of:
  - A **Hit**
  - **Suppression**
  - **Incapacitation**
- **Time** associated with each event
- **Ammunition** Expended

Accuracy

Speed

Effect

Consumables

What Is To Be Tested?

SDE

Measure impact on performance of the follow

- Sights
- Fire Control Systems
- Clothing
- Equipment (load carriage)
- Combat Body Armour
- Helmet
- Eye Protection
- Weapon Ergonomics
- C4i system & sub components

Summary and Conclusions

SDE

- The Model and Range are complimentary:
  - Validation
  - Feed models with empirical data
  - Issues that require further investigation can be explored
- The use of these tools leads to a reduction of cost, risk and time
- Modern procurement requires a system approach - ***ASPECT™*** and the ***Soldier System Assessment Range*** are tools that can support this process by providing auditable and verified **Measures of Effectiveness and Performance**

Questions?

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